AATD, 2017; 1(3): 93-99

The Effect of Meteorological Events and Air Pollution on the Occurrence of ST Elevation Myocardial Infarction

Meteorolojik Olayların ve Hava Kirliliğinin ST Elevasyonlu Miyokard İnfarktüsü Oluşumuna Etkisi

Afsin Emre KAYIPMAZ[1], Orcun ÇİFTÇİ[2], Cemil KAVALCI[1]

Öz

Giriş
Mortalite ve morbiditenin önemli bir kaynağı olan ST-segment elevasyonlu miyokard infarktüsünün (STEMI) insidansı, belirli risk faktörleri nedeniyle artmaktadır. Meteorolojik ve hava kirliliği parametrelerinin STEMI üzerine rolünün kapsamlı bir listesinin saptanmasına ihtiyaç devam etmektedir. Bu noktada, çeşitli meteorolojik olayların ve hava kirliliği parametrelerinin STEMI oranına etkisini ortaya koymayı amaçladık.
Gereç ve Yöntem
Bu retrospektif çalışma STEMI tanısı almış hastaları kapsamaktadır. Hastalara ait demografik veriler, Ankara için günlük hava sıcaklıkları (°C), nem (%), deniz seviyesindeki hava basıncı (hPa), hava olayları (yağmur, kar, sis, fırtına, dolu) ve hava kirliliği verileri elde edildi.
Sonuçlar
1709 günlük çalışma periyodunda 246 hasta STEMI ile başvurdu. Hava olayları ve STEMI insidansı arasında istatistiksel olarak anlamlı fark yoktu. Meteorolojik değişkenlerin STEMI insidansı üzerine etkilerinin 4 günlük lag analizine göre maksimum, ortalama ve minimum hava sıcaklığı ve basıncı seviyeleri arasında anlamlı fark saptanmadı. Buna karşın minimum nem, STEMI başvurularıyla lag2'de pozitif yönde koreleydi (odds oranı [OR] 95%; güven aralığı [CI] 0.986 [0.972–0.999]; p = 0.036). Hava kirliliği parametreleri arasında yalnızca nitrik oksit (OR 0.992; CI 95% [0.987–0.998]; p =0.006) ve nitrojen oksit (OR 0.994; CI 95% [0.990–0.999]; p = 0.010) lag2'de STEMI insidansı ile anlamlı biçimde koreleydi.
Sonuç
Çalışmamızın sonuçları hava kirliliğinin artmış STEMI başvurularıyla korele olduğunu açıkça ortaya koymuştur. Çevreyle ilgili iyileştirme çalışmalarının ve koruyucu sağlık hizmetlerinin yürütülmesinin STEMI insidansını azaltacağına inanmaktayız.

Anahtar Kelimeler: Hava kirliliği, meteoroloji, miyokard infarktüsü.

Abstract

Objective
An important source of mortality and morbidity, the incidence of ST-segment elevation myocardial infarction (STEMI), is increased by definite risk factors. The need to establish the role of a comprehensive list of meteorological and air pollution parameters on STEMI is ongoing. Herein, we aimed to determine the role of several meteorological events and air pollution parameters on the rate of STEMI.
Materials and Methods
This retrospective study was approved by the Baskent University Medical and Health Sciences Research Committee (Project No: KA 16/176; Date of approval: 26.04.2016). It included patients who presented to the Adult Emergency Department of Baskent University Ankara Hospital and who were diagnosed with STEMI between April 2011 and December 2015.
Results
During the 1709-day study window, 246 patients presented with STEMI. No significant correlation was found between weather events and STEMI incidence.
According to a four-day lag analysis of the effects of meteorological variables on STEMI incidence, no significant differences existed between maximum, average and minimum air temperature and pressure levels. In contrast, minimum humidity was positively correlated to STEMI admission at lag2 (odds ratio [OR] 95%; confidence interval [CI] 0.986 [0.972–0.999]; p = 0.036). Among the air pollution parameters, only nitric oxide (OR 0.992; CI 95% [0.987–0.998]; p = 0.006) and nitrogen oxide (OR 0.994; CI 95% [0.990–0.999]; p = 0.010) were significantly correlated to STEMI incidence at lag2.
Conclusion
Our study clearly demonstrated that air pollution is correlated to increased STEMI admission. Believe that improving the environment and conducting preventive healthcare would reduce the incidence of STEMI.

Keywords: Air pollution, meteorology, myocardial infarction.

İletişim Adresi:
Yrd. Doç. Dr. Afşin Emre Kayıpmaz
Başkent Üniversitesi Tıp Fakültesi, Acil Tıp Anabilim Dalı, Fevzi Çakmak Caddesi 10. Sokak No: 45 Ankara, Türkiye
Telefon: +90 312 203 68 68 • **E-posta:** aekayipmaz@baskent.edu.tr

[1] Baskent University Faculty of Medicine, Department of Emergency, Ankara, Turkey
[1] Baskent University Faculty of Medicine, Department of Cardiology, Ankara, Turkey

Makelenin Geliş Tarihi: Aralık 2016 **Kabul Tarihi:** Ocak 2017

Introduction

An important source of mortality and morbidity, the incidence of ST-segment elevation myocardial infarction (STEMI), a subgroup of acute coronary syndromes, is increased by risk factors such as diabetes, hypertension, hyperlipidemia, tobacco, cocaine, family history and physical or emotional stress. Other, less-known risk factors for myocardial infarction include traffic, air pollution and meteorological and geomagnetic factors (1, 2).

Caussin et al. investigated the role of climate in STEMI and found that short-term exposure to low air temperature was a risk factor (3). Claeys et al. reported that low air temperature was an important environmental factor for acute myocardial infarction (AMI) (4). However, a domestic study by Amiya et al. revealed that AMI presented most often in winter (5), and found no significant correlation between myocardial infarction and air pressure, sulphur dioxide concentration, or air pollution in the form of particulate matter with a mean diameter of less than 10 µm (PM10). The same study reported that temperature swings occurred frequently on days with a higher AMI incidence (6). In a recent paper, Honda et al. reported that atmospheric humidity was low on days when AMI incidence was higher than normal (7). The need to establish the role of a comprehensive list of meteorological and air pollution parameters on STEMI is ongoing.

Herein, we aimed to determine the role of several meteorological events and air pollution parameters on the rate of STEMI.

Material and Methods

This retrospective study was approved by the Başkent University Medical and Health Sciences Research Committee (Project No: KA 16/176; Date of approval: 26.04.2016). It included patients who presented to the Adult Emergency Department of Başkent University Ankara Hospital and who were diagnosed with STEMI between April 2011 and December 2015. Demographic data, including age, sex, cardiac risk factors and comorbid disorders were obtained from the patient information management system of the hospital.

Daily maximum, mean and minimum air temperatures (°C), humidity (%), sea level air pressure (hPa) and weather (rain, snow, fog, storm and hail) for Ankara were obtained from the Weather Company's website, www.wunderground.com.

Ankara is Turkey's capital city, located in central Anatolia, where a continental climate is dominant. Our air pollution data (particulate matter in two categories: mean diameter less than 2.5 µm, and mean diameter ranging from 2.5 µm to 10 µm [PM2.5–PM10], sulphur dioxide [SO2], nitric oxide [NO], nitrogen dioxide [NO2], nitrogen oxide [NOx], and carbon monoxide [CO]) were obtained from the website of the Ministry of Environment and Urbanization of the Republic of Turkey, at www.havaizleme.gov.tr.

Normally distributed variables are presented as mean ± standard deviation; non-normally distributed variables are presented as median (interquartile range [IQR]

Statistical Analysis

Statistical analysis was performed with SPSS software for Windows, version 17.0. The normality of the distribution of continuous variables was verified by a Kolmogorov-Smirnov test. A Mann-Whitney U test was used to compare independent groups of variables with non-normal distribution, while a chi-square test was used to assess the relationship between categorical variables. Generalized additive regression models were built to investigate the main and lag effects of meteorological variables on STEMI. The maximum lag followed previous studies. lag effect models and analyses were constructed with STATISTICA software, version 6.0.

A p value of less than 0.05 was accepted as statistically significant.

Results

During the 1709-day study window, 246 patients presented with STEMI, of whom 197 (80.1%) were male and 49 (19.9%) were female. The mean age was 58.6 ± 12.7 years. At least one STEMI case was presented on 220 (12.9%) of the study days. Tablo 1 shows the laboratory results for the study population. Cardiac risk factors and comorbidities are presented in Tablo 2.

Tablo 3 shows the weather and pollution on days with and without STEMI cases. No significant correlation was found between weather (rain, snow, fog, storm, hail) and STEMI incidence (p = 0.376, 0.460, 0.358, 0.942, 0.549, respectively). The comparison is summarized in Tablo 4.

Tablo 1 Laboratory results of the study population

Laboratory test	Result
BUN (mg/dL)	16 (IQR 13-19.25)
Creatinine (mg/dL)	0.92 (IQR 0.8-1.08)
Sodium (mmol/L)	138 (IQR 136-140)
Potassium (mmol/L)	4 (IQR 3.7-4.3)
Hemoglobin (g/dL)	15.1 (IQR 13.8-16.1)
Leucocyte (bin/µL)	10.65 (IQR 8.71-13.2)
Thrombocyte (bin/µL)	260.74 ± 68.65
CK-MB (U/L)	29 (IQR 23-42.75)
CK-MB Mass (ng/mL)	2.1 (IQR 0.9-5.4)
Troponin I (ng/mL)	0.06 (IQR 0.01-0.52)

Tablo 2 Cardiac risk factors and comorbidities of the study population

Risk Factor	Percentage% (n = number)
Diabetes mellitus	23.2% (57)
Hypertension	53.7% (132)
Hyperlipidemia	52% (128)
Smoking	48.4% (119)
CAD	31.7% (78)
CRF	5.6% (14)
Family History	39.8% (98)

CAD, coronary artery disease; CRF, chronic renal failure

Tablo 3 Comparison of weather and air pollution between days with and without STEMI admissions

	STEMI present (Mean ± SD)	STEMI present Median (IQR)	STEMI absent (Mean ± SD)	STEMI absents Median (IQR)	P value
Max. temperature (°C)	16.85 ± 10.041	18 (9-25)	18.11 ± 10.094	19 (11-26)	0.084
AVG. temperature (°C)	10.42 ± 8.697	10.5 (3.25-18)	11.45 ± 8.722	12 (4-19)	0.101
Min. temperature (°C)	4.03 ± 7.968	4 (-2-11)	4.90 ± 7.893	6 (-1-11.5)	0.130
Max humidity (%)	87.56 ± 11.808	93 (82-94)	87.36 ± 12.029	93 (81-94)	0.813
AVG. humidity (%)	64.32 ± 17.376	65 (50.25-77)	62.72 ± 17.153	62 (49-76)	0.196
Min. humidity (%)	34.42 ± 21.601	30 (16-50.75)	32.77 ± 20.935	27 (16-46)	0.277
AVG. air pressure (hPa)	1016.95 ± 5.338	1016 (1013-1020)	1016.18 ± 5.543	1016 (1013-1020)	0.052
Daily temperature difference (°C)	12.82 ± 5.069	13 (9-17)	13.21 ± 4.841	14 (10-17)	0.393
PM_{10} (µg/m³)	86.28 ± 49.592	77 (48.50-112.50)	83.91 ± 53.177	70 (46-107)	0.235
$PM_{2.5}$ (µg/m³)	34.25 ± 22.144	27 (21-41)	32.45 ± 18.947	27.50 (21-38)	0.717
SO_2 (µg/m³)	12.67 ± 10.095	9 (6-17)	11.39 ± 8.901	8 (5-15)	0.074
NO (µg/m³)	88.56 ± 67.955	66 (43-110)	83.48 ± 60.779	65 (45-99)	0.755
NO_2 (µg/m³)	72.08 ± 28.493	69 (56-86)	72.91 ± 28.086	69 (55-89)	0.879
NO_x (µg/m³)	163.63 ± 78.151	145 (111-204)	159.07 ± 70.840	146 (114-192.50)	0.690
CO (µg/m³)	1465.60 ± 648.003	1416.5 (1029.75-1836.25)	1335.95 ± 682.611	1235 (869-1636.25)	<0.001

PM, Particulate matter; CO, Carbon monoxide; NO, Nitric oxide; SO_2, Sulfur dioxide; NO_2, Nitrogen dioxide; NO_x, Nitrogen oxide

Tablo 4 Correlation of meteorological events and STEMI admissions

Meteorological events			STEMI admission		P value
			No	Yes	
Rain	No	n (%)	1052 (70.7%)	149 (67.7%)	0.376
	Yes	n (%)	437 (29.3%)	71 (32.3%)	
Snow	No	n (%)	1375 (92.3%)	200 (90.9%)	0.460
	Yes	n (%)	114 (7.7%)	20 (9.1%)	
Fog	No	n (%)	1398 (93.9%)	203 (92.3%)	0.358
	Yes	n (%)	91 (6.1%)	17 (7.7%)	
Storm	No	n (%)	1329 (89.3%)	17 (7.7%)	0.942
	Yes	n (%)	160 (10.7%)	24 (10.9%)	
Hail	No	n (%)	1477 (99.2%)	219 (99.5%)	0.549
	Yes	n (%)	12 (0.8%)	1 (0.5%)	

n = Number

According to a four-day lag analysis of the effects of meteorological variables on STEMI incidence, no significant differences existed between maximum, average and minimum air temperature and pressure levels.

In contrast, minimum humidity was positively correlated to STEMI admission (odds ratio [OR] 95%; confidence interval [CI] 0.986 [0.972–0.999]; p = 0.036) at lag2.

Tablo 5 lag0, lag1, lag2, lag3, and lag4 effects for humidity, pressure, and maximum, average and minimum temperature

	OR [95% CI]	P value
Max. temperature (°C) lag0	1.039 [0.988-1.093]	0.135
Max. temperature (°C) lag1	0.940 [0.876-1.008]	0.084
Max. temperature (°C) lag2	1.026 [0.956-1.102]	0.475
Max. temperature (°C) lag3	0.967 [0.900-1.039]	0.360
Max. temperature (°C) lag4	1.046 [0.992-1.103]	0.098
Avg. temperature (°C) lag0	1.005 [0.939-1.077]	0.876
Avg. temperature (°C) lag1	0.967 [0.880-1.064]	0.495
Avg. temperature (°C) lag2	0.992 [0.901-1.092]	0.868
Avg. temperature (°C) lag3	0.992 [0.901-1.092]	0.870
Avg. temperature (°C) lag4	1.063 [0.991-1.139]	0.087
Max. temperature (°C) lag0	0.975 [0.927-1.026]	0.328
Max. temperature (°C) lag1	1.003 [0.942-1.068]	0.931
Max. temperature (°C) lag2	0.977 [0.918-1.039]	0.454
Max. temperature (°C) lag3	1.038 [0.974-1.105]	0.249
Max. temperature (°C) lag4	1.030 [0.979-1.084]	0.255
Temperature difference (°C) lag0	1.035 [0.996-1.075]	0.080
Temperature difference (°C) lag1	0.974 [0.931-1.019]	0.258
Temperature difference (°C) lag2	1.017 [0.972-1.064]	0.460
Temperature difference (°C) lag3	0.970 [0.926-1.015]	0.190
Temperature difference (°C) lag4	1.009 [0.970-1.049]	0.668
Max. humidity (%) lag0	1.002 [0.983-1.022]	0.834
Max. humidity (%) lag1	1.003 [0.981-1.026]	0.798
Max. humidity (%) lag2	0.993 [0.970-1.015]	0.521
Max. humidity (%) lag3	0.995 [0.973-1.018]	0.656
Max. humidity (%) lag4	1.004 [0.985-1.023]	0.674
Avg. humidity (%) lag0	0.987 [0.970-1.005]	0.163
Avg. humidity (%) lag1	1.012 [0.988-1.036]	0.322
Avg. humidity (%) lag2	0.981 [0.958-1.004]	0.111
Avg. humidity (%) lag3	1.020 [0.996-1.045]	0.099
Avg. humidity (%) lag4	0.996 [0.978-1.014]	0.657
Min. humidity (%) lag0	0.991 [0.980-1.003]	0.145
Min. humidity (%) lag1	1.008 [0.994-1.023]	0.247
Min. humidity (%) lag2	0.986 [0.972-0.999]	0.036
Min. humidity (%) lag3	1.014 [1.000-1.029]	0.054
Min. humidity (%) lag4	0.999 [0.987-1.011]	0.890
Min. air pressure (hPa) lag0	0.980 [0.938-1.023]	0.346
Max. air pressure (hPa) lag1	1.029 [0.967-1.095]	0.367
Max. air pressure (hPa) lag2	0.968 [0.906-1.034]	0.337
Max. air pressure (hPa) lag3	1.005 [0.943-1.071]	0.885
Max. air pressure (hPa) lag4	0.979 [0.938-1.023]	0.349
Avg. air pressure (hPa) lag0	0.959 [0.915-1.004]	0.074
Avg. air pressure (hPa) lag1	1.063 [0.991-1.139]	0.086
Avg. air pressure (hPa) lag2	0.943 [0.875-1.017]	0.129
Avg. air pressure (hPa) lag3	1.019 [0.950-1.094]	0.594
Avg. air pressure (hPa) lag4	0.973 [0.929-1.019]	0.246
Min. air pressure (hPa) lag0	0.964 [0.924-1.005]	0.081
Min. air pressure (hPa) lag1	1.063 [0.999-1.130]	0.053
Min. air pressure (hPa) lag2	0.947 [0.888-1.010]	0.095
Min. air pressure hPa) lag3	1.015 [0.955-1.079]	0.630
Min. air pressure hPa) lag4	0.986 [0.946-1.027]	0.499

Tablo 6 lag0, lag1, lag2, lag3, and lag4 effects for particulate matter, sulfur dioxide, nitric oxide, nitrogen dioxide, nitrogen oxide, and carbon monoxide

	OR [95% CI]	P value
PM10 (μg/m³) lag0	1.002 [0.997-1.006]	0.436
PM10 (μg/m³) lag1	0.998 [0.993-1.004]	0.507
PM10 (μg/m³) lag2	0.996 [0.991-1.001]	0.134
PM10 (μg/m³) lag3	1.003 [0.998-1.009]	0.240
PM10 (μg/m³) lag4	0.999 [0.994-1.003]	0.566
PM2.5 (μg/m³) lag0	1.000 [0.985-1.014]	0.955
PM2.5 (μg/m³) lag1	1.000 [0.982-1.018]	0.988
PM2.5 (μg/m³) lag2	0.990 [0.973-1.008]	0.279
PM2.5 (μg/m³) lag3	1.007 [0.988-1.026]	0.489
PM2.5 (μg/m³) lag4	0.998 [0.983-1.013]	0.793
SO_2 (μg/m³) lag0	0.992 [0.968-1.016]	0.514
SO_2 (μg/m³) lag1	1.004 [0.975-1.034]	0.791
SO_2 (μg/m³) lag2	1.006 [0.976-1.036]	0.713
SO_2 (μg/m³) lag3	0.978 [0.950-1.006]	0.126
SO_2 (μg/m³) lag4	1.001 [0.976-1.027]	0.921-
NO (μg/m³) lag0	1.001 [0.997-1.006]	0.554
NO (μg/m³) lag1	1.001 [0.996-1.006]	0.729
NO (μg/m³) lag2	0.992 [0.987-0.998]	0.006
NO (μg/m³) lag3	1.003 [0.998-1.009]	0.243
NO (μg/m³) lag4	1.000 [0.996-1.005]	0.884
NO_2 (μg/m³) lag0	1.007 [0.995-1.020]	0.258
NO_2 (μg/m³) lag1	0.998 [0.982-1.015]	0.841
NO_2 (μg/m³) lag2	0.997 [0.981-1.013]	0.704
NO_2 (μg/m³) lag3	0.992 [0.976-1.009]	0.357
NO_2 (μg/m³) lag4	1.006 [0.993-1.018]	0.379
NO_x (μg/m³) lag0	1.001 [0.998-1.005]	0.459
NO_x (μg/m³) lag1	1.001 [0.996-1.005]	0.768
NO_x (μg/m³) lag2	0.994 [0.990-0.999]	0.010
NO_x (μg/m³) lag3	1.002 [0.997-1.007]	0.411
NO_x (μg/m³) lag4	1.001 [0.997-1.004]	0.768
CO (μg/m³) lag0	1.000 [1.000-1.000]	0.535
CO (μg/m³) lag1	1.000 [1.000-1.000]	0.999
CO (μg/m³) lag2	1.000 [0.999-1.000]	0.373
CO (μg/m³) lag3	1.000 [1.000-1.000]	0.940
CO (μg/m³) lag4	1.000 [1.000-1.000]	0.436

PM, Particulate matter; CO, Carbon monoxide; NO, Nitric oxide; NO_2, Nitrogen dioxide; NO_x, Nitrogen oxide; SO_2, Sulfur dioxide

Among the air pollution parameters, only nitric oxide (OR 0.992; CI 95% [0.987–0.998]; p = 0.006) and nitrogen oxide (OR 0.994; CI 95% [0.990–0.999]; p = 0.010) were significantly correlated to STEMI incidence at lag2. The results of the multivariate analysis are summarized in Tablos 5 and 6.

Discussion

We found significant correlations between STEMI admissions and minimum humidity, nitric oxide and nitrogen oxide levels at lag2. We also found a significant correlation between elevated carbon monoxide levels and STEMI admission.

Lin et al. reported that air temperatures below 1.7 °C were correlated with increased AMI admission at lag4 and lag6 (8). However, we found no significant correlation between STEMI admissions and maximum, mean, and minimum temperature differences or daily temperature swings. Lin et al. also found that PM5 concentrations higher than United States pollution-control standards, measured at between -18 °C and -12 °C, were related to an increased risk of admission for AMI (8). We found no significant correlation between PM2.5 and PM10 levels and STEMI admission.

Danet et al. showed that air pressure increments and decrements were correlated to AMI admissions (9). According to that analysis, each 10-hPa decrement in air pressure from 1016 hPa increased the risk of an adverse cardiac event by 12%, and a 10-hPa increment increased the same risk by 11% (9). Our study found no significant correlation between maximum, mean and minimum air pressure and STEMI admission.

Yildiz et al. reported no significant differences between patients with slow coronary flow and those with normal coronary flow related to maximum, mean, and minimum relative humidity (10). Wang et al. found no correlation between relative humidity and AMI admissions (11). In contrast, in our study, we found a correlation between minimum relative humidity and STEMI admissions at lag2.

Goggins et al. reported that NO2 air pollution in Hong Kong was a predictor for AMI hospitalization.

In that study, a 10 mg/m3 increment in NO2 led to a 1.1% increase in the AMI hospitalization risk. The study also revealed that an increment of 10 mg/m3 in NO2 in Taipei and Kaohsiung increased the hospitalization risk by 4.4% and 2.6%, respectively (12). We found that NO and NOx levels were correlated to STEMI admissions at lag2. Furthermore, we found a significant difference between the CO levels on days with and without STEMI admissions ($p < 0.001$).

Wang et al., in a study in Shanghai, showed that an increase in AMI admissions was correlated with short-term exposure to elevated PM2.5, PM10, and CO levels. However, unlike other studies, they found no similar correlation with NO2 and SO2 levels, and suggested that the contradiction might result from ambient air differences between Shanghai and Western cities (11).

Ebi et al. showed that El Niño (a climate pattern resulting from warm Pacific currents) increased the rate of AMI-related hospital admissions in Sacramento, US (13). Honda et al. found a positive correlation between precipitation and AMI admissions (7). Radišauskas et al., however, found no significant correlation between precipitation and wind speed and myocardial infarction-associated morbidity (14). We found no association between weather (rain, snow, fog, storm, hail) and STEMI admissions.

Some of our results were dissimilar to the literature. This may have stemmed from geographic differences, such as climate and typical air pollution levels. In Ankara, where our study was conducted, the climate is predominantly continental, with little seasonal variability (15). This may have led to the absence of correlation between STEMI and air temperature, pressure, and other meteorological parameters.

The main limitation of our study is that it was a single-center study. Although our institution is a tertiary university hospital that performs primary coronary interventions, a larger study with the participation of other hospitals in Ankara would provide more robust data.

Conclusion

We Air pollution is known to impair health (11). Climate change has also been reported to adversely affect human health in the Middle East, where our country is located (16). Our work clearly demonstrated that air pollution is correlated to increased STEMI admission. We believe that improving the environment and conducting preventive healthcare would reduce the incidence of STEMI.

Acknowledgements

The statistical analysis was performed by Seval Kul, PhD, Associate Professor for Biostatistics at Gaziantep University.

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